ENGLISH TRANSLATION

OF INTERNATIONAL APPLICATION

PCT/EP02/03164

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Office

[WIPO logo]

(43) International Publication Date:
October 3, 2002 (10/03/2002)

PCT

(10) International Publication Number:
WO 02/077595 A1

(51) International Patent Classification [7]: G01L 5/22, B62D 1/10

(21) International Application Number: PCT/EP02/03164

(22) Date of International Filing: March 21, 2002 (03/21/02)

(25) Submission Language: German

(26) Publication Language: German

(30) Priority Data:
101 14 688.4 March 23, 2001 (03/23/2001) DE

(71) Applicant *(for all designated states except the US)*: **LEOPOLD KOSTAL GMBH & CO. KG** [DE/DE]; Wiesenstrasse 47, 58507 Lüdenscheid (DE).

(72) Inventor; and
(75) Inventor/Applicant *(only for US)*: **NIEDING, Klaus**, [DE/DE]; Kölner Strasse 9, 58553 Halver (DE). **BÖBEL, Ralf** [DE/DE]; Ostkirchstrasse 99, 44269 Dortmund (DE). **BLÄSING, Frank** [DE/DE]; Kurze Strasse 15, 59457 Werl (DE).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: European Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
— *with International Search Report*
— *before expiration of the time period allowed for the changing of claims. Publication will be repeated if changes occur.*

For an explanation of the two-letter codes and other abbreviations ("Guidance Notes on Codes and Abbreviations"), please see the beginning of every regular issue of the PCT Gazette.

(54) Title: TORSION MODULE OF A TORQUE DETECTION DEVICE

[TORSIONSMODUL EINER DREHMOMENTERFASSUNGSEINRICHTUNG]

[See drawing in original document]

(57) Abstract: The invention relates to a torsion module for a torque detection device of a steering system or of a steering power-assist system of a motor vehicle. The torsion module comprises a spoked wheel (8), which can be fastened to a steering wheel and which comprises a hub (10) and a rim (11). Said rim is joined to the hub (10) via bending spokes (B) and is arranged concentric to the hub (10). The torsion module is designed in such a manner that, on at least one bending spoke (B), a pressure-sensitive or expansion-sensitive measuring sensor (D) that generates electric output signals is directly located on an area of a bending spoke (B) that is subjected to a bending in the event of a rotation angle offset between the rim (11) and the hub (10).

WO 02/077595 A1

Torsion Module of a Torque Detection Device

The invention relates to a torsion module of a torque detection device of a steering system or of a steering power-assist system of a motor vehicle, comprising a spoked wheel that can be fastened to a steering wheel and that has a hub and a rim that is joined to the hub by means of bending spokes and is arranged concentric to the hub.

Electric steering power-assist systems are being used in motor vehicles to an increasing extent. The torque exerted on the steering wheel is needed as the command variable, so that the desired steering power-assist can take place by using the ascertained torque. To detect the torque, a torsion module is required that permits a rotation angle offset between the steering wheel and the steering shaft when a torque is applied. In the case of the device described in DE 27 34 182, an object is used as the torsion module, which is formed of two rings at a distance from each other in the axial direction that are connected to each other by metal strips placed at the same angular distance from each other. While the top ring is connected in non-rotating fashion with the steering wheel, the lower ring is connected in non-rotating fashion with the steering shaft of the steering column. When a torque is applied to the steering wheel and thus to the upper ring, the metal strips undergo a torsion and are thus subjected to bending. The extent of the bending of the metal strips provides information regarding the applied torque. To ascertain this value, strip strain gauges that are attached to an evaluation unit are mounted on several of the metal strips. In the case of the object of this document, the metal strips that connect the two rings that are placed at an axial distance from each other are used as the actual torsion element. The disadvantage with the design of this torsion module is the relatively large overall height in the axial direction. It is exactly in this direction that very little space is available, especially in modern motor vehicles. Additional disadvantages related to the object of DE 27 34 182 A1 are that movements of the steering wheel relative to the steering shaft in

the axial direction also result in a deflection of the metal strips, with such a deflection being detected as a torque present at the steering wheel. Accordingly, a triggering of the steering power-assist system takes place without a torque actually being present at the steering wheel. As a result, this system is especially unsuitable for use within the context of a steering system in which the actual deflection of the wheels is produced only by means of, for example, an electrical system.

Torsion modules are also known in which two elements are placed concentric with each other as described in DE 37 37 696 A1, for example. In the case of the object of this torsion module, an interior hub is connected by means of spokes configured as bending rods to an external rim that is placed concentric with the hub. Connecting parts that transmit the given movement to one measurement transducer each are placed axially from the elements that are movable relative to each other – hub and rim –so that a rotation offset between the rim and the hub can be registered according to the eddy current principle. The measuring device known from this document also requires installation space in the axial direction that is not always available. In the case of the object of DE 37 37 696 A1, the torsion module, or more specifically, the evaluation unit coupled with it, is insensitive to or very much less sensitive to axial movements between the steering wheel and the steering shaft. While the bending spokes also bend with such a movement, such a movement does not lead to the generation of a steering signal due to the measuring sensor that is used.

Torsion modules have also been used for measuring the braking torque in a motor vehicle, as is described in DE 196 50 477 C1, for example. In the case of the torsion module described in this document, strip strain gauges are placed on the bending spokes in order to detect the rotation angle offset between the hub and the rim. In order to limit the maximum possible rotation angle offset between the hub and the rim, limit stop spokes that protrude from the hub and that engage in a recess in the rim are provided alternately with the bending spokes, which limits the maximum rotation angle offset. The wheel of a motor vehicle can be fastened to the rim. For this purpose, the rim of the torsion module is set back from the mounting surface for the tires that is formed by the

hub, so there is no danger that after a wheel is mounted on the limit stop spokes of the hub, the latter will lie against the bending spokes. A limitation of the axial movements between hub and rim is neither provided for nor necessary with the measuring device known from this document, since such movements between the hub and the brake disc mounted on the rim do not occur.

Starting from the state of the art discussed here, the invention is thus based on the task of making available a torsion module that satisfies the requirements relative to the installation space needed with a torque detection device of a steering system or steering power-assist system, which does not lead to misinterpretations in the event the steering wheel is contacted by forces acting in axial directions.

According to the invention, this task is solved in that a pressure-sensitive or expansion-sensitive measuring sensor that generates electrical output signals is placed directly on a region of a bending spoke that is subject to bending in the event of a rotation angle offset between the rim and the hub, and that placed alternately with the bending spokes are bending-resistant limit stop spokes, each having a free end that protrudes radially from the hub, and that at least the free ends of the limit stop spokes engage in a limit stop arrangement in order to prevent a metrologically effective relative movement between the rim and hub in the axial direction.

In contrast to the object of DE 37 37 696 A1, in the torsion module according to the invention the measuring sensors are located directly on the bending spokes so that the axial installation space needed is determined solely by the extension of the rim and the bending spokes in this direction. Foil-like strip strain gauges are preferred as measuring sensors, since they are especially easy to handle. The strip strain gauges are connected to an evaluation unit that does not, however, need to be part of the torsion module, but can instead be located in the steering wheel module or a steering column module, for example. Especially advantageous in terms of the object of the claimed torsion module is the concentric arrangement between the rim, configured, for example, as a ring body and thus as a rim that completely surrounds the hub, and the hub, since these three elements

are then placed essentially in one plane. To avoid a misinterpretation of measured values from the measuring sensors due to a bending of the bending spokes due to a relative axial movement between the steering wheel and the steering shaft, such a bending of the bending spokes in the axial direction is easily counteracted through placement of limit stops. Such limit stops can be realized, for example, in that placed alternately with the bending spokes are limit stop spokes, which protrude radially from the hub and each of which engages with its free end in a limit stop arrangement comprised of two limit stops placed at a distance from each other in the axial direction, wherein the inside width of the spacer opening essentially corresponds to the material thickness of a limit stop spoke. Such limit stops can be simply realized in that a spacer ring that bears an inward-pointing projection in the region of each of the free ends of a limit stop spoke is placed, for example, on both the top and bottom of the rim. In place of one or both of the rings with such projections, such a limit stop can also be formed by an additional element, for example, the base plate of a steering wheel.

To provide overload protection, it is useful to limit the possible rotation angle offset between the hub and the ring by means of limit stops. For example, to realize such a limit stop arrangement, two bulges that protrude inward from the rim can be provided, wherein they have a distance from each other such that the free end of a limit stop spoke can engage therein, and specifically, with play that corresponds to the maximum rotation angle offset between the rim and the hub.

A torsion module with such a very flat design is especially well-suited for placement in a steering wheel module of a steering wheel. With the steering wheel module, the torsion module can form the lower element that is connected with the base plate of a steering wheel. The base plate of the steering wheel is then connected to the rim, while the hub of the torsion module is mounted in non-rotating fashion to the steering shaft of a steering column. The evaluation unit for reading the measurement results of the measuring sensors, the strip strain gauges for example, is also usefully placed in the steering wheel module, which can simultaneously be the carrier for an airbag device.

In the following, the invention will be explained with the aid of an embodiment with references to the attached Figures. The following are shown:

Fig. 1: a steering wheel module for the steering wheel of a motor vehicle, in an exploded view, with a spoked wheel as the torsion module of a torque detection device,

Fig. 2: a diagonal view from below of the steering wheel module of Figure 1,

Fig. 3: a partial section along the line A-B of Figure 2,

Fig. 4: a diagonal view of the steering wheel module of Figure 1 inserted into a steering wheel, as an exploded view, and

Fig. 5: an enlarged view of the center of the steering wheel according to an additional configuration.

A steering wheel module 1 for use in a motor vehicle comprises a carrier 2 with a housing 3 and support arm arrangements 4, 5, which project upward from the housing 3 and on the top of which receptacles are placed for electric switches or switch arrangements. The support arm arrangements 4, 5 are designed so that the assemblies that are to be operated by them are placed laterally alongside the airbag cover of a steering wheel. Inserted in the housing 3 is a circuit board 6 with, among other things, the power electronics required for operating the electrical/electronic assemblies of the support arm arrangement 4, 5. The housing 3 is closed on the bottom by a lower cover 7. Forming the lower termination of the steering wheel module 1 is a spoked wheel 8, which is used as the torsion module for a torque detection device and which is kept at a distance from the lower cover 7 by a spacer ring 9. The spoked wheel 8 comprises four bending spokes, which connect a hub 10 of the spoked wheel 8 with a ring body 11 that concentrically surrounds the hub 10 in the form of a rim. The hub 10 has an assembly channel 12 with multiple toothing, which assembly channel 12 is used for holding the free end of a

steering shaft of a steering column. The spoked wheel 8 is connected in non-rotating fashion to the steering shaft of a steering column by means of the hub 10. Extending radially from the hub 10 alternately with the bending spokes B are additional limit stop spokes A, each of which engages with its free end in a limit stop arrangement, each of which consists of two bulges W_1, W_2. The limit stop spokes A are used for limiting the maximum rotation angle offset between the ring body 11 and the hub 10. Each of the bending spokes B is equipped with a strip strain gauge D (cf. Figure 2), by means of which detection takes place of the bending contribution and thus of a relative rotation angle offset between the ring body 11 and the hub 10. The strip strain gauges D are connected in a way not shown to an evaluation device that is also part of the steering wheel module 1.

In each area of its regions adjacent to the limit stop arrangements formed by the bulges W_1, W_2, the spacer ring 9 has inwardly pointing projections V that each lie against the top of the bulges W_1, W_2 and cover the limit stop gap formed by the bulges W_1, W_2. Correspondingly enclosed is the free end of the limit stop spokes A, including the bottom side, either by an additional ring 9' corresponding to the spacer ring 9, or by another element, for example, the base plate of a steering wheel. As a result of this enclosing of the free ends of the limit stop spokes A, a relative movement between the hub 10 and the ring body 11 in the axial direction is limited so that in the event of effects from forces and /or in the event of effects of bending moments introduced into the spoked wheel 8 through the steering wheel rim, impermissibly large bending of the bending spokes B does not occur. This serves to limit the elastic deformation of the spring body under the effect of unexpected forces, and to avoid misinterpretations of the strip strain gauges D assigned to the bending spokes B, which would otherwise generate a measurement signal reflecting a bending of a bending spoke B, even in the case of such relative movement.

The free ends of the limit stop spokes A are limit-stop delimited with play in the rotation direction by the bulges W_1, W_2, and are used as overload protection for the bending spokes B. By contrast, the free ends of limit stop spokes A are surrounded as closely as

possible in the axial direction, for example, by the projections V of the spacer ring 9, 9' shown in Figure 1.

All of the elements of the steering wheel module – the carrier 2, the circuit board 6, the lower cover 7, the spacer ring 9 and the spoked wheel 8 – have four bore holes, each aligned with the others, so that these elements can be jointly connected with each other by means of four fastening bolts. One of these four fastening axes is identified in Figure 1 by the reference symbol BA. In the case of the embodiment shown, the fastening bolts pass through the individual elements of steering wheel module 1 and are fastened by their threads in the center of a steering wheel. The spoked wheel 8 that is assigned to the steering wheel module 1 is thus used for coupling the steering wheel to the steering shaft.

Figure 2 shows the spoked wheel 8 as the lower part of the steering wheel module 1. In this view, it can be seen that two bending spokes B are both equipped on both sides with strip strain gauges D. The strip strain gauges D are connected in a way not shown to the circuit board 6 in the housing 3 of the steering wheel module 1. The placing of multiple strip strain gauges D on two bending spokes B is used to increase the measurement accuracy by providing a certain information redundancy. It can also be seen in this Figure that the limit stop spokes A have a much greater cross-section area than the bending spokes B, and are thus resistant to bending relative to the bending spokes B.

In this representation shown in Figure 2 of the spoked wheel 3 as the lowest part of the steering module 1, the top of the ring body 11 abuts the spacer ring 9, as a result of which the free ends of the limit stop spokes A are covered by the projections V that project inward from the spacer ring 9. In one configuration, placed adjacent to ring body 11 at the bottom is an additional spacer ring 9' (cf. Figure 3), which is constructed in the same way as spacer ring 9, which lies adjacent to ring body 11 on the top.

Figure 3 shows a section through such a limit stop arrangement formed by the two spacer rings 9, 9'. Here it can be seen that at least in the region of its free end, the thickness of a limit stop spoke A is less than the thickness of the ring body 11. This is done so that a

relative movement between the ring body 11 and the bending-resistant limit stop spoke A that is connected to the hub 10 is not impaired. The play that remains between the top or bottom of the limit stop spoke A and the projections V or V' of spacer ring 9 or 9' is so small that a bending of a bending spoke B of that extent does not lead to generation of a signal.

The assembled steering wheel module 1 shown in Figure 4 is placed axially aligned with a steering wheel 13, in that the former is mounted in the center 15 of the steering wheel 13. The steering wheel module 1 is also used for holding an airbag device, not shown, which when installed is placed between the two support arm arrangements 4, 5 with the electrical switches. The center 15 is formed by a circular recess 16 with a central opening 17 through which the hub 10 of the steering wheel module 1 passes. Also visible are threaded bore holes for the insertion of fastening bolts for mounting the steering wheel module 1 on the steering wheel 13. The top of the recess 16 lies against the bottom of the ring body 11 of the spoked wheel 8, so that through this surface, the … of the represent … under limit stop for the limit stop spokes of the spoked wheel *[phrase is garbled; words or lines appear to be missing]*.

Figure 5 shows an additional configuration of a steering wheel 13', the center 15' of which is in principle designed in the same way as the center 15 of steering wheel 13. Unlike the configuration of the recess 16 of steering wheel 13, recess 16' of steering wheel 13' has torque supports 18 that project inward like lugs, one of which is shown in Figure 5. For example, a total of three such torque supports are provided, distributed circumferentially. A spoked wheel for a torque detection device to be inserted into the recess 16' has a recess that is formed in complementary fashion in the outer ring body, so that the torque supports 18 engage positively in the ring body. In this way, the quality of a connection, for example, a bolted connection between the steering wheel base and the spoked wheel, is increased, since any conflicting actions between these two elements is prevented by the positive locking of the torque supports 18 and the ring body of the spoked wheel.

List of Reference Symbols

1	Steering wheel module
2	Carrier
3	Housing
4	Support arm arrangement
5	Support arm arrangement
6	Circuit board
7	Lower cover
8	Spoked wheel
9	Spacer ring
10	Hub
11	Ring body
12	Assembly channel
13, 13'	Steering wheel
15, 15'	Center
16, 16'	Recess
17	Opening
18	Torque support
A	Limit stop spoke
B	Bending spoke
BA	Fastening axis
D	Strip strain gauges
V	Projection
W_1, W_2	Bulge

Claims

1. Torsion module of a torque detection device of a steering system or of a steering power-assist system of a motor vehicle, comprising a spoked wheel (8) that can be fastened to a steering wheel and that has a hub (10) and a rim (11) that is joined to the hub (10) by means of bending spokes (B) and is arranged concentric to the hub (10), **characterized in that** on at least one bending spoke (B), a pressure-sensitive or expansion-sensitive measuring sensor (D) that generates electrical output signals is placed directly on a region of a bending spoke (B) that is subject to bending in the event of a rotation angle offset between the rim (11) and the hub (10), and that placed alternately with the bending spokes (B) are bending-resistant limit stop spokes (A), each having a free end that protrudes radially from the hub (10), and that at least the free ends of the limit stop spokes (A) engage in a limit stop arrangement (9, 9') in order to prevent a metrologically effective relative movement between the rim (11) and hub (10) in the axial direction.

2. Torsion module according to Claim 1, **characterized in that** strip strain gauges (D) are used as measuring sensors.

3. Torsion module according to Claim 1 or 2, **characterized in that** when multiple strip strain gauges (D) are used, at least some are placed on different sides of different bending spokes (B).

4. Torsion module according to Claim 3, **characterized in that** the rim (11) and the limit stop spokes (A) are placed so they are located in one plane and have essentially the same extent in the axial direction, and that the limit stop arrangement is formed by a limit stop that covers the region of the free ends of the limit stop spokes (A) at the top and bottom of the rim (11).

5. Torsion module according to Claim 4, **characterized in that** the limit stops are formed by rings adjacent to the rim (11).

6. Torsion module according to Claim 4, **characterized in that** at least one of the limit stops is formed by an additional component, for example, the base plate of a steering wheel (13, 13').

7. Torsion module according to one of the Claims 1 through 6, **characterized in that** provided alternately with the bending spokes (B) are bending-resistant limit stop spokes (A) that are arranged each having a free end protruding radially from the hub (10), and the free ends of the limit stop spokes (A) engage in a limit stop arrangement (W_1, W_2), by means of which the rotation angle offset in the form of a relative movement between the hub (10) and the rim (11) is limited.

8. Torsion module according to Claim 6, **characterized in that** such a limit stop arrangement is formed by two bulges (W_1, W_2) that are at a distance from each other that project inward from the rim (11), leaving a limit stop gap.

9. Torsion module according to one of the Claims 6 through 8, **characterized in that** the spoked wheel can be inserted into a recess (16') of a steering wheel (13'), and this recess has at least one lug-like, inward-directed projection as a torque support (18), which engages in positive fashion into the rim of the spoked wheel.

[Figures 1 – 5 do not require translation.]